US006892611B2

(12) **United States Patent**
Sasaki

(10) **Patent No.:** **US 6,892,611 B2**
(45) **Date of Patent:** **May 17, 2005**

(54) **SCREWDRIVER**

(75) Inventor: **Katsuhiko Sasaki**, Anjio (JP)

(73) Assignee: **Makita Corporation**, Anjo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/600,934**

(22) Filed: **Jun. 20, 2003**

(65) **Prior Publication Data**

US 2004/0055432 A1 Mar. 25, 2004

(30) **Foreign Application Priority Data**

Jun. 21, 2002 (JP) 2002-182003

(51) **Int. Cl.**[7] **B25B 23/157**
(52) **U.S. Cl.** **81/467**; 81/473
(58) **Field of Search** 81/467, 472–477

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,468,193 A	*	4/1949	Goff	464/40
2,827,779 A	*	3/1958	Holloway	81/474
4,631,992 A	*	12/1986	Eckman	81/470
4,774,864 A	*	10/1988	Dossier	81/474
5,735,183 A	*	4/1998	Sasaki et al.	81/473
6,668,690 B2	*	12/2003	Kikuchi et al.	81/473

FOREIGN PATENT DOCUMENTS

JP	61-219581	9/1986
JP	2003-220568	8/2003
JP	2003-266325	9/2003

* cited by examiner

Primary Examiner—David B. Thomas
(74) *Attorney, Agent, or Firm*—Lahive & Cockfield, LLP; Anthony A. Laurentano, Esq.

(57) **ABSTRACT**

It is an object of the invention to provide an electric screwdriver that can efficiently transmit torque for tightening a screw and stop the torque transmission. A representative screwdriver may include a motor, first and second rotating members, a tool, a torque transmission spring and a torque transmission releasing device. The torque transmission spring transmits the rotating torque of the motor from the first rotating member to the second rotating member in order to drive the tool by closely winding around the first rotating member and the second rotating member when the motor drivingly rotates the first rotating member in a predetermined rotating direction. Further, the torque transmission releasing device moves in the axial direction of the first rotating member or the second rotating member in response to the screw-tightening torque. By such movement, the torque transmission releasing device releases the close winding of the torque transmission spring around at least one of the first rotating member and the second rotating member and releases the transmission of the rotating torque of the motor to the tool.

15 Claims, 2 Drawing Sheets

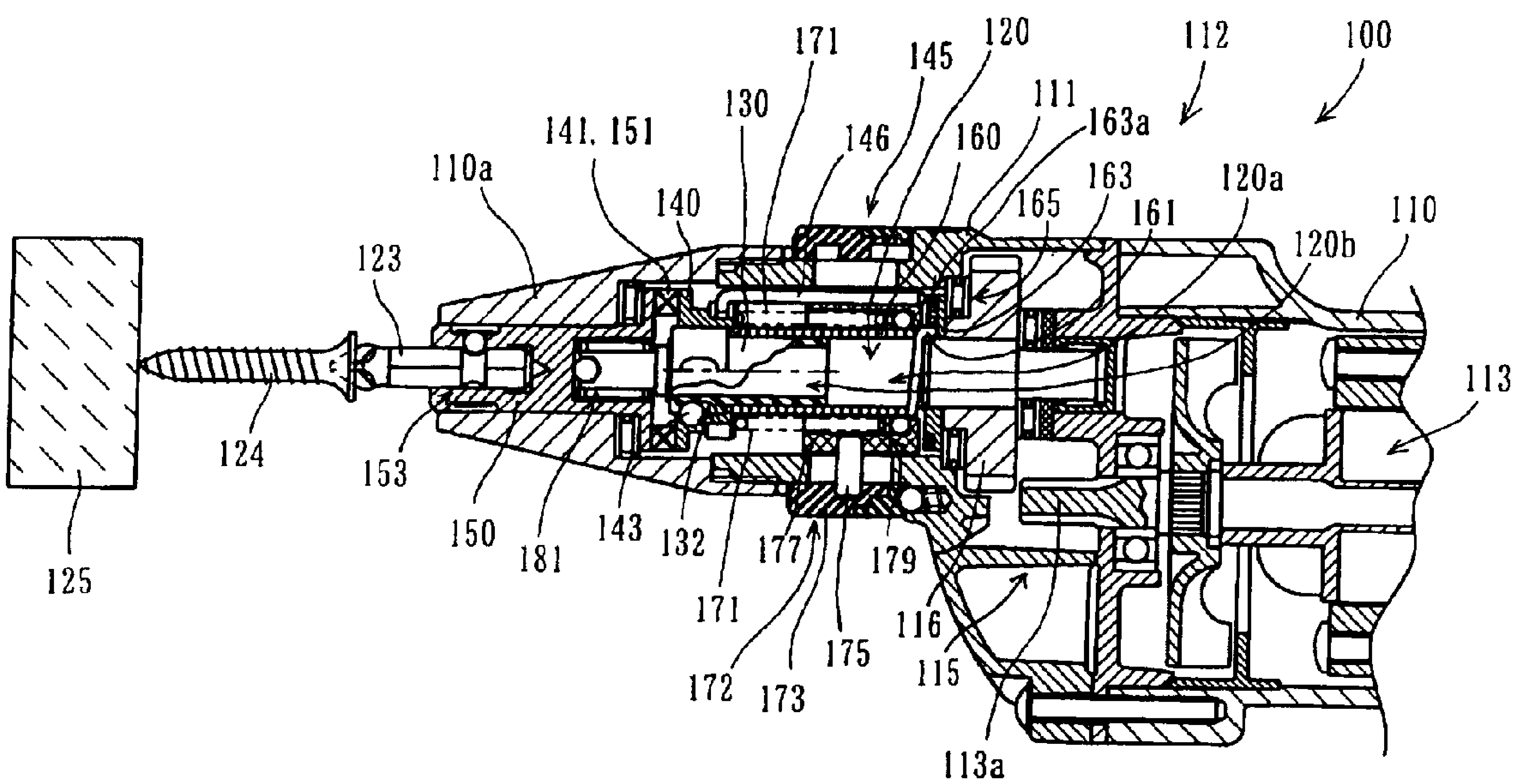


FIG. 1

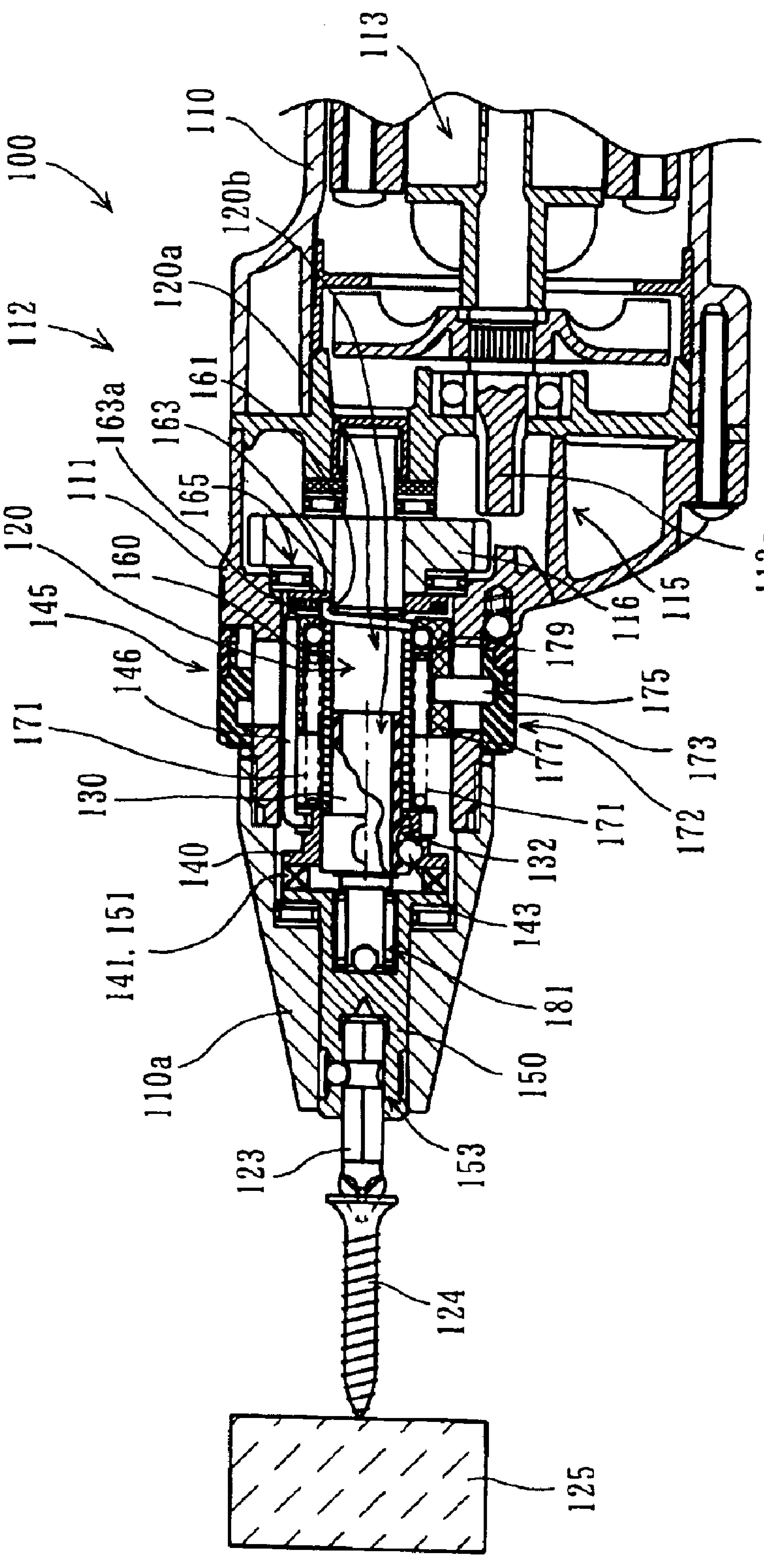
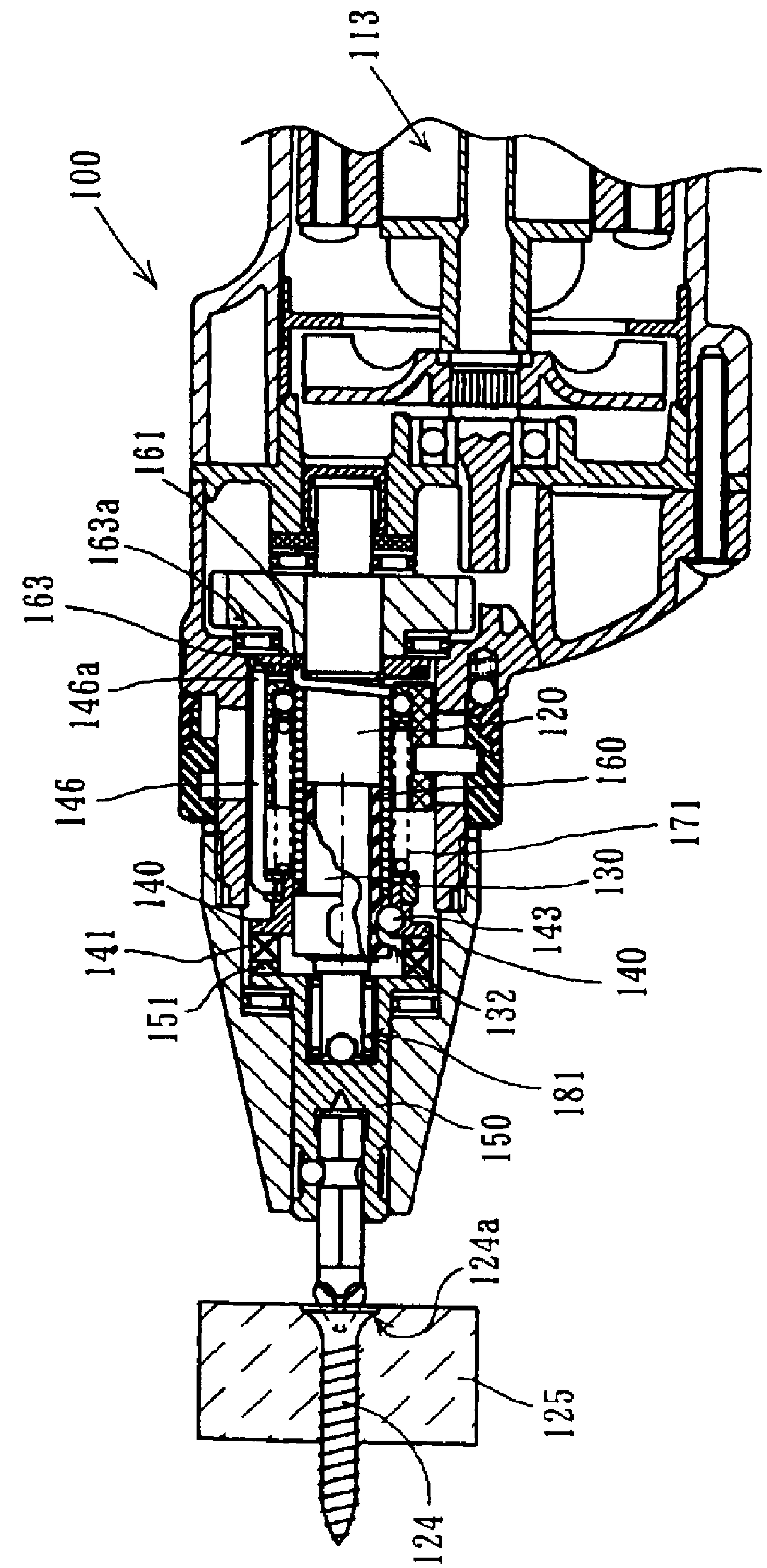

100
112
113
110
120b
120a
161
163
163a
111
165
120
160
145
146
171
130
140
141, 151
110a
123
124
125
113a
115
116
179
175
173
177
172
171
132
143
181
150
153

FIG. 2


113
100
161
163a
163
146a
146
140
141
151
120
160
171
130
143
140
132
181
150
124a
125
124

SCREWDRIVER

BACKGROUND OF THE INVENTION

The teachings of U.S. patent application Ser. No. 10/353,672, filed on Jan. 29, 2003, are herein incorporated by reference.

1. Field of the Invention

The invention relates to an electric screwdriver that can efficiently transmit torque for screw-tightening operation and release the torque transmission.

2. Description of the Related Art

An electric screwdriver is disclosed in unexamined Japanese laid-open patent publication No. 61-219581. The known screwdriver includes a silent clutch mechanism to connect a tool to a motor for transmitting the rotating torque of the motor to the tool. The silent clutch includes clutch members with clutch teeth that can be engaged with each other to transmit the motor torque to the tool. By utilizing the silent clutch mechanism, when the screw is tightened to a predetermined depth with respect to the workpiece, the clutch members can be promptly disengaged to stop transmission of the rotating torque of the driving motor. As a result, noise and vibration during screw-tightening operation can be avoided.

In the known screwdriver, the silent clutch mechanism is disposed between a rotating member on the motor side and a rotating member on the tool side. In order to transmit the rotating torque of the motor to the tool, user of the screwdriver applies a pressing load on the screwdriver while keeping the tool in abutment on the workpiece. At this time, the tool side rotating member moves toward the motor side rotating member and engages it. As a result, the motor torque is transmitted to the tool via the both rotating members which have been engaged with each other.

In the above-mentioned known technique, in order to transmit the motor torque to the tool, the user must apply a pressing load on the screwdriver to keep torque transmission from the motor to the tool via the mutually engaged rotating members. Otherwise, the torque transmission is cancelled when the pressing load of the user is not applied onto the screwdriver. However, as for a screw such as a universal joint, which is tightened in a relatively narrow work area, the user of the known screwdriver may be in difficulty to continuously apply a pressing load onto the screwdriver during the screw tightening operation.

SUMMARY OF THE INVENTION

It is, accordingly, an object of the present invention to provide an electric screwdriver that can efficiently transmit torque for tightening a screw and stop the torque transmission.

According to the present invention, a representative screwdriver may include a motor, first and second rotating members, a tool, a torque transmission spring and a torque transmission releasing device. The torque transmission spring transmits the rotating torque of the motor from the first rotating member to the second rotating member in order to drive the tool by closely winding around the first rotating member and the second rotating member when the motor drivingly rotates the first rotating member in a predetermined rotating direction. Further, the torque transmission releasing device moves in the axial direction of the first rotating member or the second rotating member in response to the screw-tightening torque. By such movement, the torque transmission releasing device releases the close winding of the torque transmission spring around at least one of the first rotating member and the second rotating member and releases the transmission of the rotating torque of the motor to the tool.

According to the present invention, the rotating torque of the motor can be transmitted by means of the torque transmission spring that closely wound around the rotating members and therefore the motor torque can be transmitted without any pressing load of the user to the screwdriver. Further, the torque transmission releasing device can immediately cancel the torque transmission in response to the screw-tightening torque. Thus, the respective screwdriver can efficiently transmit torque for tightening a screw and stop the torque transmission.

Other objects, features and advantages of the present invention will be readily understood after reading the following detailed description together with the accompanying drawings and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows essential part of an electric screwdriver according to the representative embodiment of the invention.

FIG. **2** shows the electric screwdriver in the state in which close winding of a torque transmission spring around a first spindle is released.

DETAILED DESCRIPTION OF THE REPRESENTATIVE EMBODIMENT

According to the present teachings, a representative electric screwdriver may include a motor, a first rotating member, a second rotating member and a tool. The first rotating member is driven by the motor. An AC motor, a DC brushless motor or other various motors may be utilized as a motor. Preferably, the first rotating member may be connected to the motor via a speed reducing mechanism that utilizes for example planetary gears and so on. The second rotating member is adapted to rotate by receiving the rotating torque of the first rotating member.

The tool is drivingly rotated via the first rotating member and the second rotating member for screw-tightening operation. According to the present teachings, a torque transmission spring is used to transmit the rotating torque of the motor from the first rotating member to the second rotating member. The torque transmission spring closely winds around the first rotating member and the second rotating member when the motor is driven to rotate the first rotating member in a predetermined direction. Thus, the motor torque is transmitted from the first rotating member to the second rotating member. A driver bit typically corresponds to the “tool” according to the present invention. As the “torque transmission spring”, for example, a square ring can be suitably utilized.

Further, in the present teachings, a torque transmission releasing device is provided to prevent the torque transmission spring from transmitting the motor torque. The torque transmission releasing device moves in the axial direction of the first rotating member or the second rotating member in response to the screw-tightening torque. Thus, the torque transmission releasing device releases the close winding of the torque transmission spring around at least one of the first rotating member and the second rotating member. As a result, transmission of the rotating torque of the motor from the first rotating member to the second rotating member is released. Preferably, the torque transmission releasing device may swiftly and assuredly release the transmission of the motor torque according to the screw-tightening torque. With such construction, effectiveness as a silent clutch can be ensured.

The torque transmission releasing device may be configured and arranged to release the close winding of the torque transmission spring around the first rotating member or the second rotating member or the both members. In order to release such close winding, for example, the end of the torque transmission spring may be locked. As a result, the torque transmission spring is allowed to rotate relative to the rotating member, so that it can no longer be closely wound around the rotating member. Or the torque transmission spring may be rotated relative to the rotating member in a direction opposite to the winding direction of the torque transmission spring around the rotating member, so that the close winding around the rotating member can be positively released. With respect to the movement "in response to the screw-tightening torque", for example, when the operation of tightening screws on the workpiece is nearly completed and the screw-tightening torque exceeds a predetermined torque, the torque transmission may be released.

In the screwdriver according to the present teachings, driving torque of the motor is transmitted from the first rotating member to the second rotating member via the torque transmission spring. Further, the torque transmission releasing device is adapted to appropriately release and cancel such transmission of the motor torque in response to the screw-tightening torque. Therefore, user of the screwdriver does not have to apply a pressing load on the screwdriver as in the known technique in order to engage the rotating members with each other. Thus, the screw-tightening operation can be performed efficiently.

Preferably, the torque transmission releasing device may engage the torque transmission spring so as to prevent the torque transmission spring from being closely wound in the rotational direction of the first rotating member, so that the torque transmission releasing device releases the close winding of the torque transmission spring around the first rotating member. Transmission of the motor torque and its release can be easily controlled by releasing the close winding of the torque transmission spring around the first rotating member. Preferably, in order to engage the torque transmission spring, the end of the torque transmission spring may be typically engaged such that it cannot move in the rotational direction of the first rotating member.

Preferably, the screwdriver may include a third rotating member that is disposed adjacent to the second rotating member and in the vicinity of the tool. The second rotating member may be connected to the third rotating member via a clutch member. Further, the clutch member may be adapted to move toward the first rotating member in the axial direction in response to the screw-tightening torque. The close winding of the torque transmission spring around the first rotating member may be performed or released in response to the axial movement of the clutch member. Specifically, the clutch member is disposed between the second rotating member and the third rotating member and moves toward the first rotating member in the axial direction in response to the screw-tightening torque so that the close winding of the torque transmission spring around the first rotating member is performed or released. By providing such clutch member that moves in the axial direction so as to control the close winding of the torque transmission spring, the screwdriver can be downsized in its structure.

Preferably, the clutch member may include an engagement member that extends toward the first rotating member. The clutch member may be urged toward the third rotating member by a spring. Preferably, the clutch member may be adapted to move toward the first rotating member against the biasing force of the spring when the screw-tightening torque exceeds a predetermined torque. When the clutch member moves toward the first rotating member, the engagement member engages the torque transmission spring so as to release the close winding of the torque transmission spring around the first rotating member. The clutch member is adapted to move by or against the biasing force of the spring, so that the close winding of the torque transmission spring and its release via the clutch member can be reliably controlled.

Further, preferably, the screwdriver may be configured to transmit the rotating torque of the motor to the tool via a first torque transmission path and a second torque transmission path. Through the first torque transmission path, the rotating torque of the motor is transmitted from the first rotating member to the tool via the torque transmission spring and the second rotating member. When the motor is rotated in a reverse direction so that the torque transmission by the torque transmission spring is released, the torque of the motor rotating in the reverse direction is transmitted from the first rotating member to the tool via a one-way clutch through the second torque transmission path. Specifically, when the motor is rotated in a forward direction, as mentioned above, the rotating torque of the motor is transmitted from the first rotating member to the second rotating member by utilizing the torque transmission spring. On the other hand, when the motor is rotated in a reverse direction, the torque transmission by the torque transmission spring is released. In this state, the motor torque is transmitted from the first rotating member to the tool by utilizing a one-way clutch. With such construction, motor torque can be efficiently transmitted during rotation of the motor in the reverse direction as well as in the forward direction.

Each of the additional features and method steps disclosed above and below may be utilized separately or in conjunction with other features and method steps to provide improved screwdrivers and method for using such screwdriver and devices utilized therein. Representative examples of the present invention, which examples utilized many of these additional features and method steps in conjunction, will now be described in detail with reference to the drawings. This detailed description is merely intended to teach a person skilled in the art further details for practicing preferred aspects of the present teachings and is not intended to limit the scope of the invention. Only the claims define the scope of the claimed invention. Therefore, combinations of features and steps disclosed within the following detailed description may not be necessary to practice the invention in the broadest sense, and are instead taught merely to particularly describe some representative examples of the invention, which detailed description will now be given with reference to the accompanying drawings.

FIG. **1** shows a representative electric screwdriver **100** according to the present teachings. In FIG. **1**, however, only an essential part of the body **112** of the screwdriver **100** is shown such as a motor housing **110**, a gear housing **111** and a sleeve **110***a* that is connected to the gear housing **111**. To the contrary, a grip portion that is connected to the body **112** is not particularly shown in the drawings.

The screwdriver **100** includes a motor **113**, a first spindle **120**, a second spindle **130**, a third spindle **150**, a tool bit **123**, a clutch cam **140**, a square spring **160**, a torque transmission releasing device **145**, a spring **171** and a spring biasing force adjustment device **172**. These components are disposed within the body **112**.

The first spindle **120** is a feature that corresponds to a "first rotating member" according to the present invention, the tool bit **123** to a "tool", the second spindle **130** to a "second rotating member", the clutch cam **140** to a "clutch member", the third spindle **150** to a "third rotating member" and the square spring **160** to a "torque transmission spring", respectively.

An output shaft **113***a* of the motor **113** is connected to the first spindle **120** via a speed reducing mechanism **115** which include a reduction gear **116**. However, for the sake of convenience, any other portions of the speed reducing mechanism **115** except for the reduction gear **116** are not particularly shown in the drawings. The speed reducing mechanism **115** may include a known reduction gear.

The first spindle **120** includes a large-diameter portion **120***a* and a small-diameter portion **120***b* that is contiguous to the large-diameter portion **120***a*. The second spindle **130** has a hollow sleeve-like shape and is loosely fitted around the small-diameter portion **120***b* of the first spindle **120**. As shown in FIG. **1**, the small-diameter portion **120***b* of the first spindle **120** is inserted into the hollow portion of the second spindle **130**. At this time, the outer circumferential surface of the large-diameter portion **120***a* of the first spindle **120** is flush with the outer circumferential surface of the second spindle **130**. The second spindle **130** that is loosely fitted around the first spindle **120** is coaxial with the first spindle **120** and can rotate with respect to the first spindle **120**.

A spring **160** that has a square cross section (hereinafter referred simply as "square spring **160**) is weakly press-fitted and extends around the large-diameter portion **120***a* of the first spindle **120** and the second spindle **130**. The square spring **160** comprises a winding having a square cross-section and is wound counterclockwise as viewed from the motor **113**. An end **161** of the square spring **160** can move in the rotational direction of the first spindle **120**, so that the square spring **160** is closely wound around the large-diameter portion **120***a* of the first spindle **120** and the second spindle **130**. In other words, the winding portion of the square spring **160** make contact with the circumferential surfaces of the first and second spindle **120, 130**, respectively.

The square spring **160** can be closely wound around the first spindle **120** when the end **161** of the square spring **160** is allowed to slightly move in the rotational direction of the first spindle **120**. On the other hand, the square spring **160** cannot be closely wound around the first spindle **120** when the square spring **160** is locked so that the end **161** of the square spring **160** cannot move in the rotational direction of the first spindle **120**. In the representative embodiment, normally, the square spring **160** is closely wound around the first spindle **120** when the motor **113** drivingly rotates the first spindle **120** in the forward direction or clockwise as viewed from the side of the motor **113**.

The end **161** (the right end as viewed in the drawing) of the square spring **160** is attached to a stopper plate **163**. The stopper plate **163** is fitted on the large-diameter portion **120***a* of the first spindle **120** and disposed adjacent to the reduction gear **116**. The stopper plate **163** normally rotates together with the first spindle **120** by friction between the stopper plate **163** and the circumferential surface of the large-diameter portion **120***a* and the side surface of the reduction gear **116**. However, when a stopper pin **146** locks the stopper plate **163** and prevents the stopper plate **163** from rotating together with the first spindle **120**, the stopper plate **163** is allowed to rotate relatively with respect to the first spindle **120** and the reduction gear **116** via a bearing **165**.

Clutch cam **140** is provided on the left end portion of the second spindle **130**. A recess **132** is formed in the left end portion of the second spindle **130**, and a steel ball **143** is disposed within the recess **132**. The clutch cam **140** is allowed to move by the axial length of the recess **132** in the axial direction of the second spindle **130** when the steel ball **143** moves within the recess **132**. Further, the clutch cam **140** rotates together with the second spindle **130** via the steel ball **143** that is held within the recess **132**. The clutch cam **140** and the third spindle **150** have engagement teeth **141, 151**, respectively. The teeth **141** and **151** are engaged with each other according to FIG. **1**. Although it is not particularly shown within the drawings, the teeth **141, 151** have engagement surfaces that are inclined with respect to each other. In response to the torque transmission between the teeth **141** and **151**, the teeth **141, 151** may completely engage with each other. Otherwise, one of the teeth **141** and the teeth **151** may slide relative to the other along the engagement surfaces, so that the clutch cam **140** and the third spindle **150** can move away from each other in the axial direction. In the state as shown in FIG. **1**, the steel ball **143** moves to the left end of the recess **132** within the recess **132**. Further, the clutch cam **140** is located near to the third spindle **150**. In this state, the teeth **141** and **151** engage with each other. As a result, the second spindle **130** and the third spindle **150** rotate together. The recess **132** may extend obliquely with respect to the axial direction of the second spindle **130**. In this case, the clutch cam **140** and the third spindle **150** can move relative to each other in the axial direction by the relative movement between the steel ball **143** and the recess **132**. Therefore, the teeth **141, 151** are not necessarily required to have engagement surfaces that are inclined with respect to each other.

Clutch cam **140** is urged toward the third spindle **150** by the biasing force of the spring **171**, so that the teeth **141** and **151** normally engage each other. The biasing force of the spring **171** that is exerted upon the clutch cam **140** can be changed by means of a spring biasing force adjusting device **172**. Specifically, one end (the right end as viewed in FIG. **1**) of the spring **171** is connected to the spring biasing force adjusting device **172**. The spring biasing force adjusting device **172** includes a spring support washer **179**, a torque adjusting sleeve **177**, a torque adjusting pin **175** and a torque adjusting ring **173**. When the user of the screwdriver turns the torque adjusting ring **173**, the torque adjusting sleeve **177** moves in the axial direction via the torque adjusting pin **175**. As a result, the amount of contraction of the spring **171** changes, and accordingly the biasing force of the spring **171** that is exerted upon the clutch cam **140** changes.

Further, a rod-like stopper pin **146** is coupled to the clutch cam **140**. The stopper pin **146** extends in the axial direction of the first spindle **120** and the second spindle **130**. The stopper pin **146** can rotate relative to the clutch cam **140**. Further, when the clutch cam **140** moves in the axial direction of the second spindle **130**, the stopper pin **146** moves in the axial direction together with the clutch cam **140**. Specifically, when the clutch cam **140** rotates together with the second spindle **130**, the rotational movement is not transmitted to the stopper pin **146**, so that the stopper pin **146** is held in predetermined position. On the other hand, when the clutch cam **140** moves in the axial direction of the second spindle **130**, the stopper pin **146** moves in the axial direction of the second spindle **130** together with the clutch cam **140**. The axial length of the recess **132** of the second spindle **130** defines the distance of movement of the clutch cam **140** and the stopper pin **146** as well.

When the clutch cam **140** is urged toward the third spindle **150** by the biasing force of the spring **171**, the stopper pin

146 is held apart from the stopper plate **163**. However, when the screw-tightening torque exceeds a predetermined torque as will be described below in detail, the clutch cam **140** moves rightward as viewed in the drawing in the axial direction of the second spindle **130**. As a result, the stopper pin **146** abuts against and engages with a gear-like stopper pin engagement portion **163***a* on the stopper plate **163**. Thus, the stopper pin **146** engages and retains the stopper plate **163**. At this stage, because the rotational movement of the clutch cam **140** is not transmitted to the stopper plate **163**, the stopper plate **163** is prevented from rotating together with the first spindle **120**.

As a result, the square spring **160** is prevented from rotating together with the rotating first spindle **120**. Thus, the end **161** of the square spring **160** is prevented from slightly moving in the rotational direction of the first spindle **120**. In this state, the square spring **160** can no longer be closely wound around the large-diameter portion **120***a* of the first spindle **120**. The winding engagement of the square spring **160** on the first spindle **120** is thus released. As a result, the square spring **160** is loosened and the rotating torque of the motor **113** cannot be transmitted from the first spindle **120** to the second spindle **130**, and therefore the first spindle **120** rotates idly.

Further, the left end (as viewed in the drawing) of the first spindle **120** is connected to the third spindle **150** via a one-way clutch **181**. The one-way clutch **181** allows torque transmission from the second spindle **130** to the third spindle **150** when the motor **113** drives the first spindle **120** and thus the second spindle **130** in a forward direction (clockwise as viewed from the motor **113**). On the other hand, the one-way clutch **181** directly transmits torque from the first spindle **120** to the third spindle **150** when the motor **113** is rotated in a reverse direction to rotate the first spindle **120** in the reverse direction (counterclockwise as viewed from the motor **113**). The one-way clutch **181** as itself is a known structure and therefore its detailed description will be abbreviated.

Tool bit **123** is mounted to the end of the third spindle **150** via a tool bit mounting chuck **153**. In use, a screw **124** to be tightened on a workpiece **125** is attached to the end of the tool bit **123**.

The operation and usage of the screwdriver **100** according to the representative embodiment will now be explained. User of the screwdriver **100** attaches a screw **124** to the end of the tool bit **123** and makes the end of the screw **124** into contact with the workpiece **125**. At this time, the user is not required to apply a heavy pressing load onto the screw **124**. To the contrary, only a light abutment of the end of the screw **124** against the workpiece **125** is sufficient to conduct screw-tightening operation. In this state, the user throws a trigger switch on the hand grip (not particularly shown in the drawings) in order to drive the motor **113**. When the motor **113** is driven, the first spindle **120** receives the rotating torque of the motor via an output shaft **113***a* and a speed reducing mechanism **115**.

At this stage, the stopper plate **163** rotates together with the first spindle **120** by friction. Thus, the end **161** of the square spring **160** is allowed to rotate as the first spindle **120** rotates. When the large-diameter portion **120***a* of the first spindle **120** rotates in the forward direction (clockwise as viewed from the motor **113**), the square spring **160** that is wound counterclockwise is closely wound around the large-diameter portion **120***a* of the first spindle **120** and then around the second spindle **130**. As a result, the rotating torque of the motor **113** is transmitted from the first spindle **120** to the second spindle **130** via the square spring **160**.

The square spring **160** transmits the rotation of the first spindle **120** to the second spindle **130** by its close winding around the large-diameter portion **120***a* of the first spindle **120** and the second spindle **130**. Then, the clutch cam **140** rotates together with the second spindle **130**, and the third spindle **150** receives the rotating torque by engagement between the teeth **141** of the clutch cam **140** and the teeth **151** of the third spindle **150**. The rotation of the third spindle **150** is transmitted to the tool bit **123** and the screw **124**. Thus, the screw **124** is driven into the workpiece **125**.

When the operation of tightening the screw **124** reaches a final stage and the head seat surface **124***a* of the screw **124** is seated on the workpiece **125**, the screwdriver **100** further transmits the rotating torque of the motor **113** to the screw **124** that cannot be further tightened. As a result, as shown in FIG. **2**, the teeth **141** of the clutch cam **140** comes to ride on the teeth **151** of the third spindle **150** opposing the biasing force of the spring **171**. Thus, the clutch cam **140** moves toward the first spindle **120** (rightward as viewed in the drawing) in the axial direction of the second spindle **130**. Then, the stopper pin **146**, which is arranged to move together with the clutch cam **140** in the axial direction, moves. At this time, an end **146***a* of the stopper pin **146** engages with the stopper pin engagement portion **163***a* provided on the stopper plate **163**.

Because the rotational movement of the clutch cam **140** (and the second spindle **130**) is not transmitted to the stopper pin **146** as mentioned above, the stopper plate **163** is prevented from rotating together with the first spindle **120** when the stopper pin **146** engages with the stopper plate **163**. In other words, when the first spindle **120** rotates, the stopper plate **163** in engagement with the stopper pin **146** is allowed to rotate relative to the first spindle **120** via the bearing **165**.

As a result, the end **161** of the square spring **160** is prevented from moving in the rotational direction of the first spindle **120**. In this state, the square spring **160** can no longer be closely wound around the large-diameter portion **120***a* of the first spindle **120**. The winding engagement of the square spring **160** on the first spindle **120** is thus released. As a result, the rotating torque of the motor **113** is prevented from being transmitted from the first spindle **120** to the second spindle **130** and therefore, the first spindle **120** rotates idly without transmitting the rotating torque to the second spindle **130**. Such torque transmission can be stopped instantaneously.

As mentioned above, in the screwdriver **100** according to the representative embodiment, simply by making the screw **124** in abutment on the workpiece **125** and operating the trigger switch to drive the motor **113**, the square spring **160** is swiftly and closely wound around the first spindle **120** and the second spindle **130**. Thus, the rotating torque of the motor **113** is promptly transmitted to the tool bit **123** and the screw **124**.

When the operation of tightening the screw **124** is substantially completed and the screw-tightening torque exceeds a predetermined range, the teeth **141** of the clutch cam **140** comes to ride on the teeth **151** of the third spindle **150**. Then, the clutch cam **140** moves in the axial direction and the stopper pin **146** engages with the stopper plate **163**. As a result, the square spring **160** is prevented from being closely wound around the first spindle **120**. The winding engagement of the square spring **160** on the first spindle **120** is thus released instantaneously, so that transmission of the rotating torque of the motor **113** promptly and assuredly stops.

According to the representative embodiment, the square spring **160** is used to transmit the rotating torque of the motor **113** from the first spindle **120** to the second spindle **130**. In the transmission of the rotating torque of the motor **113** by means of the square spring **160**, a torque transmission releasing device **145** can appropriately stop the torque transmission in response to the tightening torque. Therefore, it is not necessary for the user of the screwdriver to apply a strong pressing load onto the screwdriver as in the conventional technique in order to engage the rotating members with each other. Thus, the screw-tightening operation can be efficiently and easily performed.

Particularly as for a screw such as a universal joint, which is tightened in a relatively narrow work area, the user of the known screwdriver may be in difficulty to continuously apply a pressing load onto the screwdriver during the screw tightening operation. However, according to the present invention, it is not necessary to apply a strong pressing load onto the screwdriver in the screw-tightening direction in order to apply the rotating torque of the motor **113**. As a result, torque transmission can be efficiently performed or stopped even in such case.

I claim:

1. A screwdriver, comprising:

a motor,

a first rotating member that receives rotating torque of the motor,

a second rotating member that is adapted to rotate by receiving the rotating torque of the first rotating member,

a tool that performs a screw tightening operation by receiving the rotating torque via the first rotating member and the second rotating member,

a torque transmission spring that is closely wound around the first rotating member and the second rotating member when the motor drivingly rotates the first rotating member in a predetermined rotating direction, so that the torque transmission spring transmits the rotating torque of the motor from the first rotating member to the second rotating member,

a torque transmission releasing device that moves in the axial direction of the first rotating member or the second rotating member in response to the screw-tightening torque, so that the torque transmission releasing device releases the close winding of the torque transmission spring around at least one of the first rotating member and the second rotating member so as to release the transmission of the rotating torque of the motor from the first rotating member to the second rotating member, and

a third rotating member that is disposed adjacent to the second rotating member and in the vicinity of the tool, the second rotating member being connected to the third rotating member via a clutch member, the clutch member being adapted to move toward the first rotating member in the axial direction in response to the screw-tightening torque, wherein the close winding of the torque transmission spring around the first rotating member is performed or released in response to the axial movement of the clutch member.

2. The screwdriver as defined in claim **1**, wherein the torque transmission releasing device engages the torque transmission spring so as to prevent the torque transmission spring from being closely wound in the rotational direction of the first rotating member, so that the torque transmission releasing device releases the close winding of the torque transmission spring around the first rotating member.

3. The screwdriver as defined in claim **1**, wherein the clutch member includes an engagement member that extends toward the first rotating member, the clutch member being urged away from the first rotating member by a spring, the clutch member being adapted and arranged to move toward the first rotating member so as to oppose to the biasing force of the spring when the screw-tightening torque exceeds a predetermined torque, such that the engagement member engages the torque transmission spring so as to release the close winding of the torque transmission spring around the first rotating member.

4. The screwdriver as defined in claim **1**, further comprising a first torque transmission path and a second torque transmission path, wherein the rotating torque of the motor is transmitted from the first rotating member to the tool via the torque transmission spring and the second rotating member through the first torque transmission path, and when the motor is rotated in a reverse direction so that the torque transmission by the torque transmission spring is released, the torque of the motor rotating in the reverse direction is transmitted from the first rotating member to the tool via a one-way clutch through the second torque transmission path.

5. The screwdriver as defined in claim **1**, wherein the rotating members are defined by spindles that rotatably extends to the longitudinal axis thereof, respectively.

6. The screwdriver as defined in claim **5**, wherein each spindle rotates around the same longitudinal axis.

7. A method of using a screwdriver, wherein the screwdriver includes a motor, a first rotating member that receives rotating torque of the motor, a second rotating member that is adapted to rotate by receiving the rotating torque of the first rotating member, a tool that performs a screw tightening operation by receiving the rotating torque via the first rotating member and the second rotating member, a torque transmission spring that is closely wound around the first rotating member and the second rotating member when the motor drivingly rotates the first rotating member in a predetermined rotating direction, so that the torque transmission spring transmits the rotating torque of the motor from the first rotating member to the second rotating member, a torque transmission releasing device that moves in the axial direction of the first rotating member or the second rotating member, and a third rotating member that is disposed adjacent to the second rotating member and in the vicinity of the tool, the second rotating member being connected to the third rotating member via a clutch member, the clutch member being adapted to move toward the first rotating member in the axial direction in response to the screw-tightening torque, comprising:

releasing the close winding of the torque transmission spring around at least one of the first rotating member and the second rotating member by means of the movement of the torque transmission releasing device in the axial direction so as to release the transmission of the rotating torque of the motor from the first rotating member to the second rotating member in response to the screw-tightening torque, wherein the close winding of the torque transmission spring around the first rotating member is performed or released in response to the axial movement of the clutch member.

8. A screwdriver, comprising:

a motor,

a first rotating member that receives rotating torque of the motor,

a second rotating member that is adapted to rotate by receiving the rotating torque of the first rotating member,

a tool that performs a screw tightening operation by receiving the rotating torque via the first rotating member and the second rotating member, a torque transmission spring that is closely wound around the first rotating member and the second rotating member when the motor drivingly rotates the first rotating member in a predetermined rotating direction, so that the torque transmission spring transmits the rotating torque of the motor from the first rotating member to the second rotating member,

means for releasing the torque transmission by releasing the close winding of the torque transmission spring around at least one of the first rotating member and the second rotating member by means of a movement in the axial direction of the first rotating member or the second rotating member in response to the screw-tightening torque, so as to release the transmission of the rotating torque of the motor from the first rotating member to the second rotating member, and

a third rotating member that is disposed adjacent to the second rotating member and in the vicinity of the tool, the second rotating member being connected to the third rotating member via a clutch member, the clutch member being adapted to move toward the first rotating member in the axial direction in response to the screw-tightening torque, wherein the close winding of the torque transmission spring around the first rotating member is performed or released in response to the axial movement of the clutch member.

9. The screwdriver as defined in claim **8**, wherein the torque transmission releasing means engages the torque transmission spring so as to prevent the torque transmission spring from being closely wound in the rotational direction of the first rotating member, so that the torque transmission releasing means releases the close winding of the torque transmission spring around the first rotating member.

10. The screwdriver as defined in claim **8**, wherein the clutch member includes engagement means that extends toward the first rotating member, the clutch means being urged away from the first rotating member by a spring, the clutch member being adapted and arranged to move toward the first rotating member so as to oppose to the biasing force of the spring when the screw-tightening torque exceeds a predetermined torque, such that the engagement member engages the torque transmission spring so as to release the close winding of the torque transmission spring around the first rotating member.

11. The screwdriver as defined in claim **8**, further comprising a first torque transmission path and a second torque transmission path, wherein the rotating torque of the motor is transmitted from the first rotating member to the tool via the torque transmission spring and the second rotating member through the first torque transmission path, and when the motor is rotated in a reverse direction so that the torque transmission by the torque transmission spring is released, the torque of the motor rotating in the reverse direction is transmitted from the first rotating member to the tool via a one-way clutch through the second torque transmission path.

12. A screwdriver, comprising:

a motor,

a first spindle that rotates together with the motor and receives a rotating torque of the motor,

a second spindle that is adapted to rotate around the same longitudinal axis as the first spindle by receiving the rotating torque of the first spindle,

a driver bit that performs a screw tightening operation by receiving the rotating torque via the first spindle and the second spindle,

a torque transmission spring that is closely wound around the first spindle and the second spindle when the motor drivingly rotates the first spindle in a predetermined rotating direction, so that the torque transmission spring transmits the rotating torque of the motor from the first spindle to the second spindle, and

a torque transmission releasing device that moves in the axial direction of the first spindle or the second spindle in response to the screw-tightening torque, wherein the torque transmission device engages with the torque transmission spring so as to prevent the torque transmission spring from being closely wound in the rotational direction of the first spindle, so that the torque transmission releasing device releases the close winding of the torque transmission spring around at least one of the first spindle and the second spindle to release the transmission of the rotating torque of the motor from the first spindle to the second spindle.

13. A screwdriver, comprising:

a motor,

a first spindle that rotates together with the motor and receives a rotating torque of the motor,

a second spindle that is adapted to rotate by receiving the rotating torque of the first spindle,

a driver bit that performs a screw tightening operation by receiving the rotating torque via the first spindle and the second spindle,

a torque transmission spring that is closely wound around the first spindle and the second spindle when the motor drivingly rotates the first spindle in a predetermined rotating direction, so that the torque transmission spring transmits the rotating torque of the motor from the first spindle to the second spindle,

a third spindle that is disposed adjacent to the second spindle and in the vicinity of the tool, and

a clutch member that connects the second spindle to the third spindle, the clutch member being adapted to move toward the first spindle in the axial direction in response to the screw-tightening torque, wherein the close winding of the torque transmission spring around the first spindle is performed or released in response to the axial movement of the clutch member.

14. A screwdriver, comprising:

a motor,

a first spindle that rotates together with the motor and receives a rotating torque of the motor,

a second spindle that is adapted to rotate by receiving the rotating torque of the first spindle,

a driver bit that performs a screw tightening operation by receiving the rotating torque via the first spindle and the second spindle,

a torque transmission spring that is closely wound around the first spindle and the second spindle when the motor drivingly rotates the first spindle in a predetermined rotating direction, so that the torque transmission spring transmits the rotating torque of the motor from the first spindle to the second spindle,

a third spindle that is disposed adjacent to the second spindle and in the vicinity of the tool, and

a clutch member that connects the second spindle to the third spindle, wherein the clutch member includes an engagement member that extends toward the first spindle, the clutch member being urged away from the first spindle by a spring, the clutch member being adapted and arranged to move toward the first spindle so as to oppose to the biasing force of the spring when the screw-tightening torque exceeds a predetermined torque, such that the engagement member engages the torque transmission spring so as to release the close winding of the torque transmission spring around the first spindle.

15. A screwdriver, comprising:

a motor,

a first spindle that rotates together with the motor and receives a rotating torque of the motor,

a second spindle that is adapted to rotate by receiving the rotating torque of the first spindle,

a driver bit that performs a screw tightening operation by receiving the rotating torque via the first spindle and the second spindle,

a torque transmission spring that is closely wound around the first spindle and the second spindle when the motor drivingly rotates the first spindle in a predetermined rotating direction, so that the torque transmission spring transmits the rotating torque of the motor from the first spindle to the second spindle,

a torque transmission releasing device that moves in the axial direction of the first spindle or the second spindle in response to the screw-tightening torque, wherein the torque transmission device engages with the torque transmission spring so as to prevent the torque transmission spring from being closely wound in the rotational direction of the first spindle, so that the torque transmission releasing device releases the close winding of the torque transmission spring around at least one of the first spindle and the second spindle to release the transmission of the rotating torque of the motor from the first spindle to the second spindle, and

a first torque transmission path and a second torque transmission path, wherein the rotating torque of the motor is transmitted from the first spindle to the tool via the torque transmission spring and the second spindle through the first torque transmission path, and when the motor is rotated in a reverse direction so that the torque transmission by the torque transmission spring is released, the torque of the motor rotating in the reverse direction is transmitted from the first spindle to the tool via a one-way clutch through the second torque transmission path.

* * * * *